Regional Migration, Insurance and Economic Shocks: Evidence from Nicaragua

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Abstract
In developing countries most migrants are internal migrants, yet there is limited evidence to show whether internal migrants represent a source of insurance to the original household or vice versa. I test the insurance role of transfers sent and received by young migrants by estimating the causal impact of income shocks in the migrants' locations of origin and destination on inter-household transfers. Rainfall shocks are found to lead to changes in income but not in consumption, indicating that households are able to smooth consumption. I find that young migrants provide insurance to their original households and that the level of insurance increases when migrants and households are exposed to low correlated rainfall shocks. This article shows evidence of bilateral insurance between rural migrants and their original households when the differences in the intensity of the shocks increase. These results provide new evidence of risk-sharing strategies among households geographically spread around a country.

KEYWORDS
Internal migration, remittances, risk, insurance, weather shocks

JEL CLASSIFICATION
O12, O15, F24, D1

1. Introduction

Rural households in developing countries are exposed to many kinds of risk. In a context characterized by limited access to credit and insurance markets, households have developed different strategies to cope with adverse economic shocks (De Weerdt and Dercon, 2006; Fafchamps, 2003; Morduch, 1995; Rosenzweig and Wolpin, 1993). However, most of these strategies offer little protection from aggregate shocks because these affect almost everybody in the same location. In order to handle local common shocks, households may rely on a network of relatives extending beyond the borders of their community.

This article investigates whether the transfer of funds between parents and children in their early adulthood living away from their original communities functions as a form of insurance in rural Nicaragua. While most of the experimental literature on remittances has focused on the insurance role of remittances from international migrants, this article looks at regional migration. Regional migration, understood as the sum of domestic and south-to-south migration is more common than international migration in areas of rural poverty, especially among young adults. While international migration to developed countries is expensive and risky (de Brauw and Carletto, 2012), young

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adults, for work or family reasons, frequently move regionally, to locations nearby or far off. The potential impact of regional migrants is intensified by the fact that regional remittances, though smaller as individual sums, tend to be redistributed back to the poorest sectors of society in greater and more regular amounts than international remittances are (Deshingkar and Grimm, 2004).

I use information on the location of migrants to simultaneously examine exogenous income shocks in their places of origin and at their destination and analyse whether migrants provide insurance to their original household, and whether they receive insurance from it. To study this bilateral insurance arrangement, the study estimates the causal impact of income shocks on transfers from the migrant to the household of origin (hereafter, 'remittances') as well as transfers from the original household to the migrant ('transfers'). Given that rain-fed agriculture is the main source of income and rainfall deficits negatively affect household income, I exploit local variations in rainfall to analyse the insurance contract. I use a two-agent risk-sharing model to show that the bilateral transfer of funds is a function of income shocks at the origin and the destination. The model assumes perfect commitment and serves to capture the direction of the insurance response to rainfall shocks but not its magnitude.

I use two rounds of data from a household survey implemented in rural Nicaragua. Migrants in the sample were members of their original household when the baseline survey was conducted in 2000. Ten years later, when the follow-up survey was implemented, they were part of a new household. I restrict the analysis to those household members who were traced in the 2010 follow-up survey, that is, young migrants who were between the ages of 15 and 21 in 2010. By focusing on this age cohort I analyse the informal arrangements in a sample in which all the migrants were long-term household members before their migration. Although they were young, around 90 percent of the sample cohort of migrants was working in 2010 and 50 percent had an off farm source of income. The age-range of this cohort includes the ages when important life events (finishing school, beginning work, leaving home, getting married) occur in developing countries. The transitions involved may bring some risks and uncertainties that affect the economic relationship with other members of the household. Using the GPS coordinates of households and migrants, I merged the two rounds of household data with the historical data on rainfall available for a grid of 0.0755°(every 8 km).

I found evidence that young migrants provide insurance to their households of origin. Remittances are adjusted by the shocks at the origin but transfer receipts are not adjusted by the shocks occurring at the destination. This result indicates the presence of insurance contracts similar to those found in the literature on international remittances. I find that remittances received from migrants compensate for 28 percent of the reduction in household agricultural income due to a decrease of one standard deviation in the accumulated rainfall. This amount is far from full insurance, but it shows that, at least in the short run, households remain part of the risk sharing network of the young adults who move within a region.

While urban migrants insure their household of origin, average rural migrants neither provide nor receive such insurance. I show that the lack of insurance among rural migrants is explained by the high levels of correlation between shocks and that when the differences increase in the intensity of rainfall shocks, rural migrants supply insurance to their original household. Moreover, the results show that they also receive insurance from their original household, indicating the existence of a bilateral insurance arrangement, in which rural migrants provide twice as much as the insurance they receive from their household of origin. However, this asymmetry in the level of insurance can be explained by differences in vulnerability to the specific shock (rainfall shock) analysed in this paper. Indeed, results show that bilateral insurance is found among the poorest households in this context, which are especially vulnerable to rainfall shocks. [1] To the best of my knowledge this is the first study to analyse how insurance varies as the level of correlation changes between shocks at two locations of this kind.

In the last decade a strand of the literature on migration has focused on understanding the role of remittances as an instrument to cope with economic shocks. Clarke and Wallsten (2003) and Yang and Choi (2007) find that international remittances increase when households in the country of origin are exposed to adverse weather events. At the country level, Yang (2008*a*) has compiled further evidence on this insurance mechanism. He finds that hurricanes lead to increases in migrants' remittances, and that these cover 20 percent of the damage caused in the poorest developing countries.

These studies have in common that they focused on the way in which overseas remittances adjust to income shocks to the migrants' original community. Few studies look at the effect of exogenous shocks on remittances at their destination. Yang and Martínez (2005) and Yang (2008*b*) analyse how outcomes in non-migrating household members in the Philippines react to variations of international exchange rates. They find that exogenous increases in migrant resources have positive effects on investment outcomes in the migrants' original location, suggesting a positive income effect on the amount of remittances sent. Looking at long-distance internal migration, Gröger and Zylberberg (2016) provide evidence on the insurance role of internal remittances from labour migrants in the aftermath of a strong typhoon in Vietnam. But the results of Gröger and Zylberberg study apply only to labour migration, whereas my work focuses on a broader sample of migrants who move away, not only for labour purposes, but also to marry and settle in another location than that of their family.

This article also relates to De Weerdt and Hirvonen (2016), who examine how income shocks and household consumption co-vary across linked households in Tanzania. They find that network members living in other communities share about 2.7 percent of their consumption growth by insuring the family members living in their original household, but they do not find evidence of bilateral insurance. As is the case in a large strand of the literature on risk sharing, (Altonji, Hayashi and Kotlikoff, 1992; Townsend, 1994; Udry, 1994), De Weerdt and Hirvonen (2016) focus on analysing how shocks and consumption co-vary across households in a social network. However, they do not indicate how risk sharing takes place. My article differs from these by focusing on the actual flows of transfers between households and migrants, which reveals the mechanism behind the risk-sharing arrangement.

In this respect, this article contributes to the literature on risk management by highlighting the role of regional and internal migrants on informal insurance arrangements. It has been argued that information and enforcement problems between the members of the same community are likely to be small, creating an adequate environment for establishing risk sharing networks with relatives and friends within the community's borders. An important characteristic of local aggregate shocks is that households cannot rely on local networks to cope with them, and hence they need to rely on households that are not exposed to the same shocks, that is, their network of migrants.

The remainder of the present article is set out as follows. Section 2 presents the insurance model from which the reduced forms are derived. Section 3 summarises the data, describes the sample of migrants and the remittance behaviour. Section 4 presents the weather shocks. In section 5, I present the specification strategy, and analyse selection into migration. Section 6 discusses the results and other risk coping strategies. Section 7 concludes.

2. Conceptual Framework

2.1. Model

I follow the literature on risk sharing and set up a simple benchmark model of perfect commitment from which the reduced form equations to test the insurance hypothesis are derived. This section builds on Fafchamps and Lund (2003) and Yang and Choi (2007).

Risk-sharing theory states that if there is a Pareto-efficient allocation of risk across network members, consumption should not be affected by individual income shocks. I simplify the risk-sharing model to a model that considers two individuals, $i = \{1, 2\}$, and assume that both members are risk-averse, that they have identical preferences and that they can neither borrow nor save.

Individual i has an uncertain income $y^i_{s^g}$, depending on the natural conditions $s^g \in S$ in his location g. Individual i consumes $c^i_{s^g}$ and derives instantaneous utility $U(c^i_{s^g})$. Let the utility be separable and twice differentiable, with $U'_i > 0$ and $U''_i < 0$. The model can be solved as a social planner maximisation problem in which a weighted sum of each individual utility is maximised.

Pareto efficiency requires the ratio of marginal utilities between members to be constant in any natural conditions, with the planner's weights ω_i satisfying $0 < \omega_i < 1$ and $\omega_1 + \omega_2 = 1$. Let us assume that individual utility takes the form of a constant absolute risk aversion function with all individuals having the same coefficient of absolute risk aversion θ,

$$U(c^i_{s^g}) = -\frac{1}{\theta} e^{-\theta c^i_{s^g}} \tag{1}$$

The first-order conditions include $\omega_i e^{-\theta c^i_{s^g}} = \lambda$, where λ is the Lagrange multiplier associated with individual i's resource constraint. Efficient risk sharing implies that individual consumption depends only on mean consumption and on each individual's Pareto weight relative to the other's. Given that λ is the same for all individuals, I can equalise the marginal utilities for each individual. Taking logs and rearranging:

$$\frac{1}{\theta}(\ln \omega_1 - \ln \omega_2) = c^1_{s^g} - c^2_{s^g} \tag{2}$$

The planner's weights do not depend on the state of nature, and are thus constant. I define the budget constraint for individual 1 as,

$$c^1_{s^g} = y^1_{s^g} + NTr^1_2 \tag{3}$$

where NTr^1_2 accounts for the net value of the transfers received by individual 1 and sent by individual 2. Note that NTr^1_2 enters individual 1's budget constraint as positive but individuals 2's budget constraint negatively ($c^2_{s^{g'}} = y^2_{s^{g'}} - NTr^1_2$). Individual income $y^i_{s^g}$ is decomposed into a permanent component ($\tilde{y}^i$) and a transitory component ($y'^i_{s^g}$), such that only transitory income depends on the state of nature: $y^i_{s^g} = \tilde{y}^i + y'^i_{s^g}$. Rearranging equation 2, I obtain the equation for the net value of transfers for individual

1:

$$NTr_2^1 = \frac{1}{2}\{(\tilde{y}^2 - \tilde{y}^1) + (y'^2_{s^g} - y'^1_{s^g}) + \frac{1}{\theta}(\ln \omega_1 - \ln \omega_2)\} \tag{4}$$

2.2. Hypotheses and Empirical Test

I use Equation 4 to derive a reduced form equation for the empirical test on the insurance role of transfers. Because the function of Pareto weights and the permanent income component $\tilde{y}_i$ do not depend on the state of nature, I capture them by a vector of individual and household characteristics X_{12}. In the risk-sharing literature, the term average consumption is replaced by village or network shocks, Yang and Choi (2007) replaces it by time effects. I proxy the permanent income of both individuals using data on education, household characteristics, location and household members. Given that rain-fed agriculture is the main economic activity, I use rainfall shocks to proxy the transitory income. Rainfall shocks are represented by $z^i_{s^g}$, such that $\frac{\partial y'^i_{s^g}}{\partial z^i_g} < 0$. I assume that the income response to rainfall shocks is heterogeneous across individuals, whether they live in the same location or in different locations.

Under this set of assumptions, I can derive a reduced form equation from 4:

$$NTr_2^1 = \alpha + \beta_1 z^2_{g'} + \beta_2 z^1_g + \gamma X_{12} + \epsilon_1 \tag{5}$$

where ϵ_1 is an idiosyncratic error term. Unlike Equation 4, Equation 5 does not impose a symmetrical contract. An important assumption behind Equation 5 is that it allows income response to rainfall shocks to be heterogeneous across individuals, which may capture differences in productivity and in income diversification. Under this assumption, shocks in more urbanised areas are expected to have less impact on household income than shocks in locations where rain-fed crops are the main source of income. However, when income responses to shocks are exactly the same, there is no adjustment to the net amount of funds transferred.

Equation 5 is used to test whether the net value of transfers between i and j is affected by the shocks occurring at the locations of both individuals. To test whether any adjustment is driven by an insurance behaviour or whether it is driven by other factors, I derive two different equations from Equation 5 from individual 1's perspective:

(1) Remittances: transfers from 1 to 2

$$R^1 = \alpha^R + \beta^R_1 z^2_{g'} + \beta^R_2 z^1_g + \gamma^R X_{12} + \epsilon^R_1 \tag{6}$$

(2) Transfers: transfers received by 1 from 2

$$Tr^1 = \alpha^{Tr} + \beta^{Tr}_1 z^2_{g'} + \beta^{Tr}_2 z^1_g + \gamma^{Tr} X_{12} + \epsilon^{Tr}_1 \tag{7}$$

Using Equations 6-7 I test two hypotheses:

(1) Individual 1 insures individual 2: $\beta^R_1 > 0$, when individual 2 is exposed to a negative rainfall shock in g', the value of remittances that 1 sends to 2 increases.
(2) Individual 2 insures individual 1: $\beta^{Tr}_2 > 0$, when individual 1 is exposed to a negative rainfall shock in g, the value of the transfers that 1 receives from 2

increases.

My identification strategy allows me to directly test both hypotheses. In addition I estimate the impact of rainfall shocks in the sender's location on the out-flow of transfers, captured by β_2^R and β_1^{Tr}. I expect the rainfall shock in the sender's location to decrease the total value of the transfers sent, through an income effect.

3. Data

I use two years of data from a household survey in rural Nicaragua collected to evaluate a Conditional Cash Transfer programme (CCT): a pre-programme census collected in 2000 of all residents in the target communities and a long-term follow-up survey conducted between November 2009 and November 2011 (hereafter, the 2010 survey). Information from the 2000 census data is used to construct the variables capturing household characteristics at the baseline, before the decision to migrate was taken.

In 2010, households and individuals in the target group, which included all households that had split-up and that contained the main caregiver, an original panel household member (under 21 in 2010) or a child of an original household member, were tracked across Nicaragua and to Costa Rica. At the household level the rate of attrition was below 8 percent.

The sample of migrants was restricted to respondents in the target group who at the time of the follow-up survey were old enough to have migrated. The analysis focused on those respondents between ages of 15 and 21 in 2010, who in 2000 were living at what was considered the original household (67 percent were living in their parents' house). Because adults in this age cohort were tracked to their location of destination, I have detailed information on the migrants' locations (GPS coordinates) and on their economic activities. The target sample contained 3,995 individuals between ages 15 and 21 in 2010, among whom 3,540 were found and surveyed in 2010 (the attrition rate was 11.38 percent). Among those found, the sample is restricted to original households visited and interviewed before August 2010, which is before the harvest in the first agricultural season of 2010. Households interviewed afterwards reported agricultural outputs from the first season of 2010 instead of outputs from the 2009 agricultural seasons. I focused on the rainfall shocks affecting agricultural outputs from the first agricultural season in 2009, because outputs for the second season might have been incomplete. [2] This study focuses on the sample of long-term migrants, defined as those absent for more than nine months in the last 12, or people who have left more recently but have no plans to returning in the short run, and who at the time of the follow-up were members of a new household, i.e. 864 migrants (see Figure 1).

Figure 2 shows the geographical distribution of migrants into three flows: migrants staying in their municipalities of origin (dashed regions) or in neighbouring municipalities; migrants moving to the agricultural frontier (north-east) or to another remote rural area; and migrants moving to the Pacific Coast and around Managua and San José (Costa Rica). This third flow was formed by urban migrants, while the first two were rural migrants and migrants moving to small urban areas. The distribution of rural migrants across space allows me to exploit the space-variation of local income shocks at the destinations. The household survey and tracking records provide reliable data on the current location of attritors, which allows me to conduct a robustness check by including in the analysis the migrants who were not found in 2010. This information is also available for migrants older than 21 years old who were living in the household of origin in 2010 but were not part of the tracking protocol (see discussion in the supplemental material).

Regional migration in this area is important, 50 percent of the households have at least one migrant and only 2.5 percent of these are international migrants. I distinguished between local and non-local migrants using as a reference the rainfall data cell in which each household was contained. I defined local migrants as those who lived in the same rainfall grid cell as their original household. Non-local migrants lived in a different rainfall grid cell, so I could measure any difference in rainfall between them and their original household. This group comprised 430 migrants, of whom 384 were interviewed before the first harvest in 2010. The main findings apply to this pool of 384 migrants. The average (median) distance between the household of origin and the migrant destination was 900 metres (400 meters) for local migrants and around 40 kilometres (16 kilometres) for non-local migrants.

Apart from these migrants, I had information on household migration, which refers to the migration of all members to the same location. Household members who migrate from a migrant household are reclassified as individual migrants and included in the corresponding category.

To distinguish between urban and rural migrants I linked the household database to DMSP-OLS Night-time Lights. The images identify lights from cities, towns, and other sites with persistent lighting. Elvidge, Baugh, Kihn, Kroehl and Davis (1997) show that light density at night is a robust proxy of economic activity. For Nicaragua, I use a threshold of seven (of the 6-bit 0-63.0 range of the DSMP-OLS city lights produced) based on urban sites observed using Google Maps and data collected in the household survey. Around 80 percent of migrants moved to rural areas, while fewer than 20 percent migrated to urban areas. Given that only 2 percent of migrants moved to Costa Rica, I conducted the analysis of figures for domestic migrants and migrants to Costa Rica together.

Table 1 shows the descriptive statistics for the cohort of interest in 2010. Around 60 percent of migrants were women, differences across locations are not large but they suggest that women move especially to rural areas. [3] Differences in other individual characteristics across migrants and non-migrants are driven by those moving to urban areas, who on average had two more years of education and came from wealthier households (see table A1 in the appendix for baseline characteristics at the household level). Almost all the young adults in the sample were working at the time of the follow-up survey, although migrants to urban areas are less likely to be working than others, but are more likely to work in non-agricultural activities. Around 40 percent of the sample of stayers and 50 percent of the urban migrants were studying in 2010; however, it should be noted that most of those studying in 2010 were also involved in some economic activity. While around half of the sample of migrants was married, only 9 percent of those who stayed at home were married at the time of the follow-up survey. Differences were especially large between local and non-local rural migrants, and the latter were also more likely to have children. This pattern is in line with the fact that around 70 percent of rural migrants (mainly women, local and non-local) moved to get married, while migrants to urban areas are more heterogeneous and also move to study, work, or to find a better economic situation.

On average, migrants are less likely than stayers to own a house and they own less land. However, migrants reported higher values of annual consumption per capita than stayers - this applies especially to urban migrants.

The bottom panel of table 1 shows descriptive statistics of the flows of funds between migrants and their households of origin. I have information on the total amount of remittances sent and transfers received by 90 percent of the sample of migrants. The data on remittances and transfers on each migrant were reported by a member of the original household (usually the household head) and not by the migrant. As a result, even when the migrants were found and interviewed later than the original household, I have information on their transactions at the date when the original household was surveyed (96 percent of the households of origin were interviewed before August 2010). The data refer to transfers of funds made during the 12 months before the follow-up survey in 2010. Around one third of the sample of migrants received transfers and/or sent remittances. Table 1 shows that at the extensive margin, the rates of migrants sending and receiving remittances were not significantly different across destinations.

At the intensive margin, urban migrants sent more remittances (in annual values) than rural migrants and local migrants. In terms of transfers received, local and other rural migrants received transfers to the same value as those that they sent. The inflow of transfers among rural migrants was greater than the outflow of remittances, although the difference was not significantly different from zero. In contrast, urban migrants were net contributors. On average they sent 34 USD more than they receive from their original household. This is in line with the fact that urban migrants reported annual consumption per capita to be about 2.8 times larger than in their original household (1.5 times higher in the case of non-local rural migrants).

Twenty two percent of migrants (local and non-local) who sent remittances to the household of origin in the previous 12 months were also receiving transfers, which supports the hypothesis of a cooperative contract in which both parties are actively involved.

4. Rainfall Shocks and Agricultural Outcomes

4.1. Rainfall Shocks

The historical rainfall data are taken from Uribe (2011) and are available from 1979 to 2009. The data are available for a grid of 0.075°(every 8 km) and are interpolated from weather stations (from the Nicaraguan Institute of Territorial Studies, INETER) and satellite data measured at a resolution of 0.1875°(every 20 km) from NARR (the North American Regional Reanalysis). [4]

For the sample of households of origin I used data from 53 grid cells, and for the sample of migrants the data came from 127 grid cells. Rainfall variables for each grid cell were constructed separately and migrants were matched to the rainfall grid cells using GPS coordinates for the location of their household of origin and on their current location at a destination.

Rainfall deficits are important for agricultural output in Nicaragua. Insufficient rainfall over an extended period has strongly negative consequences for yields. Data from the community questionnaire in 2010 show that 93 percent of the community leaders who completed the survey reported experiencing a drought in the previous 12 months.

This article followed Macours, Premand and Vakis (2012) and focused on water deficits during critical windows in the growth cycle. In particular, I looked at the accumulated rainfall between June and July for the first growing season (*Primera*) in 2009. As the agronomy literature indicates, the large losses to grain yields are caused by water deficits during the flowering season (Calvache, Reichardt, Bacchi and Dourado-Neto, 1997), which, depending on the crop variety, occurs 48-60 days after sowing maize and 31-38 days after sowing beans.

The measure of rainfall variability is defined as deviations from the historical mean of accumulated rain divided by the standard deviation for each grid cell (z-scores). Hence, it is constructed using standardized deviations of accumulated rainfall from the historical mean at each location, and captures rainfall events that are unexpected, given those in previous years.

For ease of interpretation, the z-score rainfall variables were multiplied by minus one so they could be read as negative shocks (higher values signify higher negative deviations). Figure 3 shows the distribution of rainfall in standard deviation units. Very few households and only slightly more migrants experienced positive deviations of accumulated rain for this period (surplus): only 6 percent of the total sample actually experienced accumulated rainfall above 0.5 standard deviations from the historical mean. Therefore, the rainfall variable captures mainly rainfall deficits. For households in the municipalities of origin, the first growing season in 2009 was dryer than normal. Almost 17 percent of households of origin were exposed to rainfall deficits of a standard deviation of one or more (Figure A1 in the appendix shows the variation of rainfall shocks across regions). Figure 3 also shows that differences in rainfall intensity between migrants' origin and their destination locations were large and heterogeneous.

4.2. Agricultural outcomes

The most common activity in the region is farming: 89 percent of the household heads were involved in agricultural activities, and 90 percent of the land cultivated was used to grow temporal crops, basically beans and maize. Table 2 shows the effect of rainfall fluctuations on food production, harvest outcomes, income, and consumption among the households of origin with and without migrants.[5] A one standard deviation increase in the rainfall-deficit reduces annual food production by 39 log points in the sample of households with migrants and by 27 log points in the sample of households without migrants. This fall is driven by a drop in the production of basic grains, and is confirmed by an increase in the amount of grains bought. One standard deviation increase in the rainfall deficit reduces the probability of having grains to sell by 10 percent among households with migrants and by 14 percent among households with no migrants. The consumption of grains produced at home also falls, while it increases the likelihood of losing the harvest. These findings provide evidence of the direct effects of rainfall deficits on agricultural production, whether a household has regional migrants or not.

One standard deviation increase in rainfall deficit decreases agricultural households' per capita income for households with migrants by 80 log points (and by 64 log points for households without migrants), indicating that household income is quite sensitive to rainfall shocks. While the effect of rainfall shocks is negative and significantly different from zero in both types of household, income from other economic sources in households with migrants is less vulnerable to rainfall fluctuations. One standard deviation increase in rainfall deficit reduces the total household income for households without migrants by 15 log points, but I find no effect among households with migrants. This indicates that households may have different strategies to cope with and manage economic shocks. Table 2 also shows that rainfall shocks do not have an impact on consumption either of food or non-food items per capita, suggesting that households manage to protect themselves against shocks even when an important source of income is jeopardized.

5. Empirical Specification and Sample Selection

5.1. Empirical Specification

The previous section shows that rainfall deficits in the sample represent credible income shocks among households in rural areas. I estimated the following reduced-form equations for individuals m (migrant) and h (household of origin) living in locations d (destination) and o (origin) respectively:

$$Tr_h^m(s^o, s^d) = \alpha^{Tr} + \beta_o^{Tr} z_{s^o}^h + \beta_d^{Tr} z_{s^d}^m + \gamma^{Tr} X_{mh} + \epsilon_m^{Tr} \tag{8}$$

$$R_h^m(s^o, s^d) = \alpha^R + \beta_o^R z_{s^o}^h + \beta_d^R z_{s^d}^m + \gamma^R X_{mh} + \epsilon_m^R \tag{9}$$

where Tr_h^m is an indicator variable equals to one if m receive transfers from the original household h or a continuous variable capturing the annual amount of transfers received, and R_h^m is an indicator variable equals to one if m remits or a continuous variable capturing the annual amount of remittances sent by migrant m to household h [6]; $z_{s^o}^h$ and $z_{s^d}^m$ measure rainfall at the origin and destination location respectively in standard deviation units; X_{mh} includes regional fixed effects at origin and at destination, location variables including altitude, vegetation index, distance to school and level of urbanization in 2000, dummies for stratification groups and a set of baseline control variables, collected in 2000, at the household and at the individual level.[7]

In addition, ϵ_i is an idiosyncratic error term. To account for the possible correlation in outcomes within locations at origin and at destination, the error term was adjusted for two-way clustering at the origin grid cell level and at the destination grid cell level.

If income shortfalls from rainfall shocks are partly insured, β_d^{Tr} and β_o^R should be positive. The size of β_d^{Tr} relative to β_o^R provides some insight into whether the insurance contract is symmetric and both parties are insured at the same magnitude, or is asymmetric. However, the difference between coefficients might also be driven by differences in the vulnerability to rainfall shocks at either location. Therefore, Equations 8-9 cannot be used to test for full insurance. Indeed, for urban migrants, rainfall fluctuations at destination do not represent an income shock [8] and thus for urban migrants I restricted the analysis to unilateral insurance contracts and estimated the following equations:

$$Tr_h^m(s^o) = \alpha^{Tr} + \beta_o^{Tr} z_{s^o}^h + \gamma^{Tr} X_{mh} + \epsilon_m^{Tr} \tag{10}$$

$$R_h^m(s^o) = \alpha^R + \beta_o^R z_{s^o}^h + \gamma^R X_{mh} + \epsilon_m^R \tag{11}$$

In addition, I use Equations 10-11 to analyze the impact of rainfall shocks on the flows of transfers between local migrants and their household of origin. Local migrants are defined as migrants living in the same grid cell than their original household, and therefore in this setting they are exposed to exactly the same rainfall shock.

Estimates from Equations 8 and 11 may be biased if the likelihood of being exposed to a rainfall shock was correlated with the time-invariant household characteristics or if the decision to migrate had been determined by the intensity of rainfall fluctuations in each location. Covariates in X_{mh} helped to reduce this bias, and in the next section I show that neither the decision to migrate nor the choice of destination were correlated with rainfall variability at either location.

Finally, I looked at the net impact of shocks on the flow of transfers, defined as, $NTr^m_h(s^g) = Tr^m_h(s^g) - R^m_h(s^g)$. The reduced form equation estimated is,

$$NTr^m_h(s^o, s^d) = \alpha^{NTr} + \beta^{NTr}_o z^h_{s^o} + \beta^{NTr}_d z^m_{s^d} + \gamma^{NTr} X_{mh} + \epsilon^{NTr}_m \tag{12}$$

and for urban and local migrants,

$$NTr^m_h(s^o) = \alpha^{NTr} + \beta^{NTr}_o z^h_{s^o} + \gamma^{NTr} X_{mh} + \epsilon^{NTr}_m \tag{13}$$

Equations 8-13 were estimated by OLS,[9].

5.2. Selection into migration

The self-selection process of migrants restrains me from drawing any inference on the impact of migration on individual and household outcomes. The self-selection of migrants could threaten the validity of the identification strategy if the decision to migrate is driven by rainfall fluctuations at origin and/or at destination, or if households send migrants away from time to time when they are exposed to large variations in accumulated rainfall. To explore whether this is the case, I analysed the correlation between a measure of the rainfall variation over the previous ten years and the decision to migrate. I constructed a coefficient of the variations in the accumulated rainfall between June-July from 2000 to 2008 at the migrants' location of origin and of destination $CV = \frac{STD_{(00-08)}}{MEAN_{(00-08)}}$.

Table 3 reports the estimates of the coefficient of variation and of rainfall deficit in 2009 on the decision to migrate by destination. I estimated a Linear Probability Model, such as the following:

$$Y^m_d = \alpha + \beta_o z^h_{s^o} + \beta_d z^m_{s^d} + \gamma X_{mh} + \epsilon_m \tag{14}$$

where Y^m_d is an indicator variable equals to one if migrant m moves to location d. Where location d represents a local, non-local, rural or urban location, or a location in which rainfall deficit in 2009 differed by 0.10, 0.25, 0.5, 0.75 or 0.9 points from the rainfall deficit at location o. $z^h_{s^o}$ and $z^m_{s^d}$ captured the rainfall at the migrant's original location and at her/his destination. Notice that the measure of rainfall can be the coefficient of variation of accumulated rain or rainfall deficit in 2009; X_{mh} includes the list of individual and household covariates as Equations 8-13. The results confirm that neither the decision to migrate nor the choice of destination were correlated with rainfall fluctuations in the previous ten years, nor with rainfall deficits in 2009 at the migrants' origin or destination. Estimates are very small and not significantly different from zero. Restricting the sample to those who had migrated, I found that migrating to a non-local rural area was negatively correlated with an increase of rainfall deficit at the location of origin. This result suggests that the point estimates of negative rainfall shocks at origin on transfers and remittances could suffer from negative bias. In such a case, my specification would underestimate the impact of shocks at the place of origin on the level of remittances and overestimate the impact of shocks at the place of origin on the total amount of transfers received. Therefore, selection in rural migration may threaten the estimates of the income effect but not the presence of an insurance mechanism through remittances, which if anything, would be underestimated.

Table A2 in the appendix shows the p-values of joint significance test by groups of covariates in X_{mh}. The results show that while individual and household characteristics are important determinants of migration by type of location (local, rural and urban), they are not correlated with the probability of migrating to one specific location depending on deviations of accumulated rainfall. Moreover, the bottom panel of Table A2 shows that migrants' characteristics do not have predictive power over rainfall deviations at migrants' locations of origin and destination. This result is important because it provides further evidence that migration in this setting is not driven by rainfall deficits.

As a robustness check, I computed the yearly correlation in accumulated rainfall and in rainfall deviations from the mean between origin and destination using 30 years of rainfall data. I found a positive correlation, which indicated that migrants' placement does not respond to insurance considerations against rainfall shocks.

Finally, I showed that among households with and without migrants, food production and agricultural income are negatively correlated with rainfall deficit. Although the strategies to cope with and manage economic shocks may differ across households, rainfall deficits affect agricultural production and households' income, whether or not the household has a migrant. This provides further evidence of the independence between rainfall fluctuations and the selection into migration, as those with migrants are not less or more exposed to rainfall fluctuations than households without migrants.

6. Results

6.1. Main results

Top panel of Table 4 shows the estimated coefficients for the sample of non-local migrants, including rural and urban migrants. One standard deviation increase in rainfall deficit in a migrant's place of origin increases the probability of sending remittances by 9 percentage points and raises the total amount of remittances sent by 28.34 USD, indicating that migrants provide insurance to their original households. However, rainfall deficits at a migrant's destination have no impact on the total amount of transfer receipts, suggesting that migrants are not insured by their original household.

The last column shows that those exposed to negative rainfall shocks are net recipients of funds. One standard deviation increase in rainfall deficit at a migrant's origin reduces the net value of the transfers that they received by 36.30 USD, indicating that the net contribution of the migrant increases. Conversely, when migrants are exposed to negative shocks at their place of destination their net benefits increase by 17.82 USD, half of the change observed when shocks occur at their place of origin. Taken together, these results indicate that migrants are insuring their original household. The lack of impact of rainfall shocks on the probability of receiving transfers indicates that the adjustments on transfers comes mainly from migrants who were already engaging in economic transactions.

Table 4 shows that both flows of funds are adjusted by shocks occurring at the sender's location. The impact of shocks at his/her place of destination is large, though not significant at the 10 percent level. A drop in household income due to rainfall shocks reduces the total amount of transfers and remittances sent, suggesting that the liquidity of households and migrants is constrained, especially the households of origin.

In net values, I find that the effect of rainfall shocks to the households of origin and destinations is different in magnitude, indicating that the insurance contract is not symmetric (p-value 0.112). However, this asymmetry may reflect differences in the vulnerability to rainfall shocks. [10]

How much is the insurance provided by the migrant? One standard deviation decrease of accumulated rainfall decreases the household agricultural income by 95.45 USD. Remittances from this pool of migrants compensate for 28 percent of the reduction in household agricultural income. Although this level of insurance is far from full insurance, it is large when compared to the average annual value of remittances. These results confirm that households in poor rural areas, in order to face agricultural shocks, exploit the spatial distribution of members of their extended network, in this case young migrants.

Equation 4 suggests than when income shocks at origin and at destination are exactly the same, there will be no adjustments in the net amount of funds transferred. The bottom panel of Table 4 confirms this result: rainfall shocks do not have any impact on the amount of transfers received and remittances sent. It should be noted that the percentage of local migrants receiving transfers and sending remittances is very similar to among non-local migrants (32 and 34 percent, respectively). However, in the case of local migrants both sides may be suffering equally from the deficits of rainfall, indicating that income response to rainfall shocks may be homogeneous among households living in the same location.

6.2. Spatial distribution of migrants: urban versus rural migrants

To analyse how the correlation between income shocks affects the insurance role of remittances and transfers, I split the sample into migrants moving to urban areas and migrants moving to rural areas. This exercise allowed me to explore further whether the asymmetry observed in Table 4 is explained mainly by different income-generating activities at origin and at destination.

The migrants moving to urban areas come from wealthier households and have more years of education than other migrants. About 50 percent of the sample of urban migrants reported an agricultural income equal to zero. Indeed, Table 5 shows that their income was less vulnerable to rainfall deficits and therefore less correlated to income shocks occurring at their location of origin. Since rainfall shocks in urban areas have no impact on household income, I restricted the analysis to the impact of rainfall deficits in the place of origin on transfers and remittances, and estimate Equations 10, 11 and 13.

On the other hand, around 60 percent of non-local migrants moved to rural areas, where they worked mainly in agricultural activities, making this group highly vulnerable to rainfall shocks. Table 5, columns (3)-(4) shows that rural migrants' agricultural production and agricultural income were affected by rainfall shocks at destination. One standard deviation increase in rainfall deficit at the destination increased by 42 log points the amount of grains bought and reduced the probability of consuming home-produced grains by 16 log points. As with households of origin, one standard deviation increase in rainfall deficit reduces household agricultural income by 70 log points but it does not affect the total of either household income or household consumption, indicating that migrants' households manage to protect themselves against shocks. I use this sub-sample of migrants to analyse the prevalence of bilateral insurance contracts.

Table 6 shows the estimated coefficients by type of migrant. One standard deviation decrease in rainfall in the place of origin raises the amount of remittances sent by an urban migrant by about 65.08 USD, almost twice the effect found in Table 4. The income effect is also strong and large; migrants' probability to receive any transfer decrease by 18 percentage points and total transfer receipts decrease by 36.69 USD in the face of negative shocks at origin. Finally, the net amount of transfers falls by 76.47 USD. Remittances from urban migrants compensate for 67 percent of the reduction in household agricultural income due to a one standard deviation decrease in accumulated rainfall at origin. [11]

The rainfall deficits could affect individuals in urban areas through indirect channels, such as an increase in food prices. The annual data of prices at the departmental level suggest that prices in urbanised regions, such as Managua, Granada, and the Pacific coast, were less volatile in 2010 than prices in the rural regions. As expected, markets in urban areas are more integrated than in rural areas and therefore are less likely to be affected by local fluctuations in rainfall.

Table 6 shows that there is no evidence of any insurance mechanism functioning between average rural migrants and their original households. The estimated coefficient on the net value of transfers received shows that migrants are net contributors when their original household is exposed to negative rainfall shocks, and are net beneficiaries when shocks occur at destination; however, the size of the estimates suggests that the adjustment responds to an income effect rather than to an insurance effect. Section 5.2 shows that migrating to a non-local rural area is negatively correlated with an increased rainfall deficit at the location of origin; hence estimates of the impact of rainfall deficit at origin on the transfers received by the migrant may capture their selection into rural migration rather than an income effect.

Differences between urban and rural migrants may be explained by migrants' characteristics, but the lack of insurance provided by the average rural migrant may be explained by the fact that they and their original household may be exposed to highly correlated weather shocks. Using the rainfall grid to distinguish local and non-local migrants has the drawback that rural non-local migrants may still be living very close to their communities of origin and therefore remain exposed to highly correlated shocks.

To analyse whether this was the case, I computed the absolute value of the difference between rainfall deviations and, based on the result, constructed several samples of migrants. [12] This strategy allowed me to reduce spatial correlation without imposing any assumption on the income effect of rainfall fluctuations at each location.

Figure 4 shows the results from Equations 8 and 9 on different samples of migrants. The vertical axis shows the coefficients capturing the insurance role of transfers and remittances, β_d^{Tr} and β_o^R respectively. The values on the horizontal axis represent the minimum difference in absolute values between rainfall deviations at the origin and destination in each sample ($\delta_{abs} = |z_{s^o} - z_{s^d}|$).

Both graphs show a positive relationship between the absolute difference between shocks and the level of insurance. Plot (a) in Figure 4 shows that the level of insurance provided by the household to the migrant increases as the shocks between locations become less correlated. The peak of insurance exceeds 10 USD when the absolute difference in rainfall intensity across locations is between 0.25 and 0.4 points (p-values between 0.09 and 0.14). Although small, this result suggests that households of origin may provide some insurance to their migrants when exposed to negative rainfall shocks.

Plot (b) in Figure 4 shows that when the correlation between rainfall shocks shrinks, rural migrants provide insurance to their original household. Rural migrants exposed to shocks at least 0.45 points larger or smaller than their household of origin adjust their remittances by almost 22 USD, which accounts for one third of the impact observed among urban migrants. This result is important because it indicates that even migrants with low levels of education (around five years of schooling), working in agricultural activities, and who are married and economically independent (77 percent are married and 62 percent are household heads) are still providing insurance to their original households.

6.3. Heterogeneous effects

This section studies whether the asymmetry in the bilateral insurance contract captures differences in agents' vulnerability to rainfall shocks or differences in agents' insurance behaviour. To proxy the level of migrants' vulnerability to rainfall shocks I divided the sample of non-local rural migrants by individual characteristics. I considered the following dimensions: (i) migrants working in livestock husbandry; (ii) migrants whose household income per capita at destination was below the median value in 2010; (iii) migrants from extremely poor households [13]; (iv) migrants who were married; and (v) migrants who owned their housing. Figure 5 reports the point estimates with 90 percent confidence intervals for the rainfall deficits at origin and at destination on the main outcomes (probability of sending transfers, probability of sending remittances, the annual value of transfers and the annual value of remittances) by migrants' category.

Figure 5 shows that migrants involved in livestock husbandry provide insurance to their household at origin when they are exposed to a negative shock at the place of origin. This result supports the hypothesis that households rely on remittances sent from migrants whose income is less vulnerable to rainfall shocks, and this at the same time explains the lack of a bilateral insurance contract since these migrants are more likely to be able to protect themselves by diversifying their economic activities.

Migrants involved in agricultural activities, not including livestock husbandry, are more likely to be vulnerable to rainfall shocks, and their income is presumably more closely correlated to that of their original household. However, only 23 percent of migrants in my sample worked in agriculture alone, not including livestock husbandry; thus, given the limited number of observations I cannot analyse the insurance contract between them and their household of origin. To test whether a bilateral insurance may exist between households that are especially vulnerable to shocks, I looked at two measures of economic status. Figure 5 shows the point estimates for rural migrants whose per capita income in their destination household in 2010 was below the sample median. The measure of income included agricultural income as well, and hence captured part of the shock. I found that rural migrants whose income was below the sample median were more likely to insure the household of origin but also to receive insurance. I found a similar result when looking at migrants coming from extremely poor households of origin. In both cases, the insurance operated mainly at the extensive margin and points out to a bilateral contract in which both sides are insured. Finally, I analysed the insurance contract among migrants who were married or who owned their housing, as proxies for settled migrants. The results show that settled migrants provide insurance to their households of origin, suggesting that the insurance contract is not driven solely by migrants who are temporarily away from their communities of origin. Moreover, the results show that among migrants owing a property one standard deviation increase in rainfall deficit at destination raises the probability of receiving a transfer from the household of origin, indicating the presence of a bilateral insurance contract. Table A4 in the appendix shows that the main results hold after restricting the sample of migrants to those between ages of 18 and 21. Indeed, the insurance mechanism is stronger among this cohort, while the income effect is still present, indicating that none of the results was driven by the youngest group of migrants.

Overall, the results point to the presence of bilateral insurance arrangements. When both sides of the contract are vulnerable to rainfall shocks, both sides receive protection in form of transfers of funds. Distance between locations does not seem to affect the level of insurance, indicating that somehow the lack of correlation between shocks, positively correlates with distance, prevailing over any hypothetical increase in transaction and information costs. Moreover, bilateral contracts operate among poor migrants and among settled migrants living in rural areas. Finally, urban migrants and rural migrants working in livestock husbandry provides high levels of insurance to the household of origin. However, we cannot test whether, in the face of income shocks at destination, they receive protection from their original households.

6.4. Other risk-coping mechanisms

Table 2 shows that households are able to smooth consumption even when their income has shrunk. While rainfall shocks have an impact on both groups of households, those with no migrants may have different strategies to manage and cope with economic shocks. The estimates suggest that, in per capita terms, total income in households with regional migrants is less vulnerable to weather shocks. Looking at different coping strategies, Table 7 shows that changes in household composition and increases in remittances received are the main coping strategies identified among households with migrants. Among households with no migrants, I found evidence of assets depletion. Aggregates on remittances received by any migrant who was living in the household in 2000 suggest that these households do not receive transfers from other migrants either. These results should be interpreted with caution, as the two types of household, with and without migrants, are not really comparable. Migrants come from households with different observable characteristics, which may be correlated with the decision to migrate, with the choice of destination, and with the implementation of an insurance mechanism. These characteristics might also determine the degree of vulnerability of each household.

7. Conclusion

Using household survey data on poor communities in rural Nicaragua, this article has examined how inter-household transfers between young migrants and their original household are adjusted in the face of income shocks. I looked at the impact of income shocks in the place of origin as well as at the destination on different types of migrant and showed that regional migration served as an insurance mechanism against agricultural shocks.

The results indicate that risk-sharing arrangements are heterogeneous by destination and economic activity and status. Those who are exposed to less-correlated shocks are more likely to participate in an insurance arrangement. For instance, urban migrants and migrants diversifying their economic activities provided a greater level of insurance than other rural migrants. On average, remittances received from non-local migrants compensated for 28 percent of the reduction in household agricultural income, while one urban migrant compensates for 67 percent of agricultural income lost. In this case, smoothing is considerable when taking into account the fact that transfers and remittances are only a small percentage of consumption per capita.

I analysed other mechanisms that households may use to face income shocks and smooth consumption. The results indicated that adverse rainfall shocks led to a reduction in assets and livestock, especially among households with no young regional migrants. This could in the long run lead to poverty traps through asset depletion. I find some evidence that this may be less important for households that rely on migrants for insurance.

An important contribution of this article is that it provides evidence of the presence of a bilateral insurance mechanism in which both parties are insured. This type of contract is observed among the poorest rural migrants, among settled rural migrants, and when rural migrants and their original households are exposed to rainfall shocks of different intensities. When rainfall intensity between locations differs by 0.3 points, the level of insurance provided in both directions is similar (around 10 USD for one standard deviation increase in rainfall deficit). Above this threshold, the bilateral contract is asymmetric. The estimated insurance shocks occurring in the place of origin on remittances doubles the insurance effect on shocks occurring at the destination of the transfers received by migrants. However, these results may capture only differences in agents' vulnerability to rainfall shocks and not differences in agents' insurance behaviour.

To my knowledge this article provides the first empirical evidence of a bilateral insurance contract across regional migrants moving from and to rural areas. The results highlight that, in the short run, young migrants are able to keep their risk-sharing network in the community of origin even if they migrate to remote rural areas. These results are at odds with the findings for India by Munshi and Rosenzweig (2016), reporting that individuals are reluctant to migrate for fear of losing access to their local risk-sharing networks; that is, that local caste networks restrict mobility in rural areas. In my setting, I cannot test for the presence of other risk-sharing networks, because my information covers only transfers from former household members. Even so, the results show the presence of a risk-sharing network between young migrants and the households of origin. These networks extend beyond the borders of the community and provide insurance not only to the household of origin but also to migrants moving to other rural areas.

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Notes

[1]This paper shows that urban migrants provide insurance to their household of origin when rainfall shocks occur to their community of origin. However, rainfall shocks do not have an impact on migrants' incomes in urban areas; hence, I cannot test whether households of origin also insure urban migrants when they are exposed to other negative income shocks.

[2]The data collection for the household follow-up survey started at the beginning of November 2009 and the second harvest season in Nicaragua ended at the end of November.

[3]To study whether there are gender differences in shock responses I introduced a dummy variable to capture whether the migrant was female, K, and an interaction term between K and each rainfall shock in Equations 7-13 $T_h^m(s^o, s^d) = \alpha^T + \beta_o^T z_{s^o}^h + \delta_o^T(z_{s^o}^h * K) + \beta_d^T z_{s^d}^m + \delta_d^T(z_{s^d}^m * K) + \lambda K + \gamma^T X_{mh} + \epsilon_m^T$. Overall, the interaction term was non-significantly different from zero, indicating the absence of a gender heterogeneity effect. Given these results and the small sample size I ran all the analyses with the male and female migrants pooled together.

[4]In order to capture Nicaraguan micro-climates I had to use rainfall data at the local level. The small size of the cells in the gridded database allowed me to identify local rainfall shocks. The network of weather stations used for the interpolation was large (205 stations), and the spatial distribution of stations across Nicaragua was relatively homogeneous (the national average was approximately 23 rain stations per average size of department (6,755 km^2)), except for the eastern regions (departments of "Región Autónoma Atlántico Norte" (RAAN) and "Región Autónoma Atlántico Sur" (RAAS)). Migrants in the sample moving to these two departments represented only 2.5 percent of the non-local regional migrants.

[5]Migrants refer to the specific set of young migrants who lived in these households 10 years ago. Households may have had older migrants who were not residing with the original household at the time of the baseline interview.

[6]The results are robust to different specifications of the continuous outcome variables (results available in the supplemental material).

[7] Household baseline controls included: log of per capita expenditures, household composition dummies (by age groups), whether the household owned the house, log of land size, distance to school in minutes, number of children of the household head, years of education of the household head, age of the household head, this age squared, and dummy variables for whether the household head was active in agriculture, the household head had no completed grades of schooling, and was female. Individual baseline controls included: migrant's years of education, year age dummies, together with dummies for whether the migrant's mother and father lived in the house and whether the respondent was a child of the household head.

[8]Rainfall may affect food prices at the local level, but it is very unlikely to affect market prices in Managua and San José.

[9]Results are robust to different specifications of the continuous outcome variables: inverse hyperbolic sine transformations and square root of annual values. Results are available in the supplemental material.

[10]The supplemental material includes a discussion on the impact of rainfall shocks on prices. The data show that local prices are not affected by non-local shocks.

[11] Table A3 in the appendix shows that including rainfall shocks at destination does not affect the estimated coefficients of shocks at origin, while none of the coefficients on rainfall shocks at destination are significantly different from zero.

[12] Including interactions between shocks at origin and at destination does not change the results: the interaction is not significantly different from zero.

[13] Households are considered extremely poor if they belong to the three first strata (over 7) of the poverty index used in the CCT programme to select beneficiaries.

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Tables and Figures

Figure 1. Sample of respondents 15-21 years old in 2010

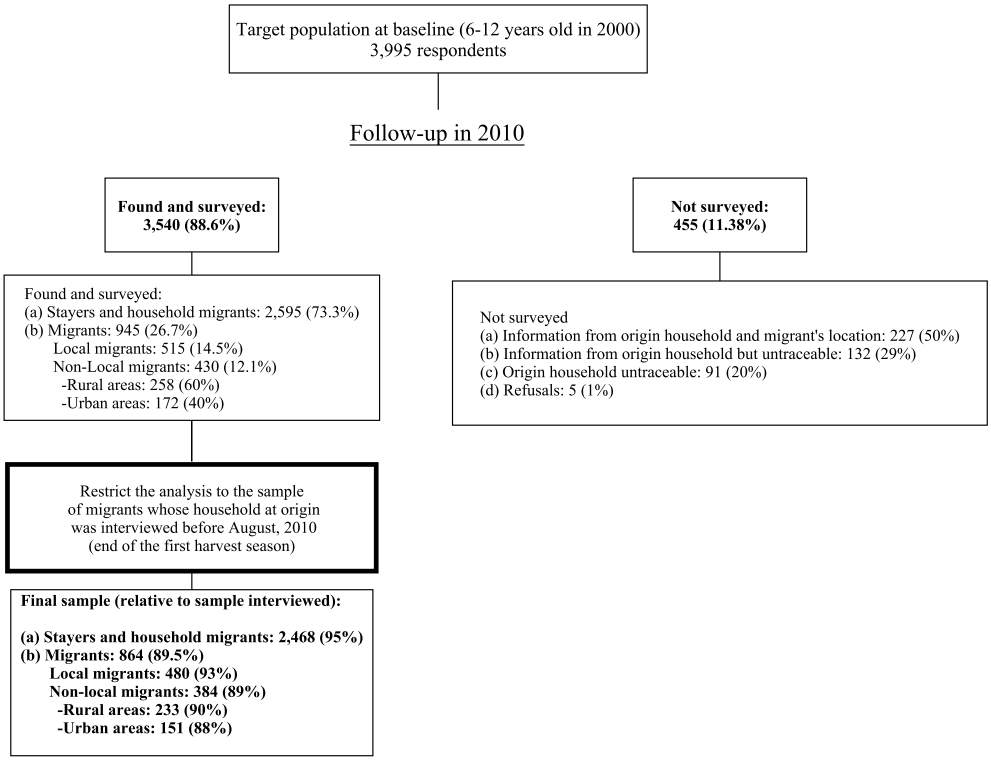


Figure 2. Distribution of migrants by destination

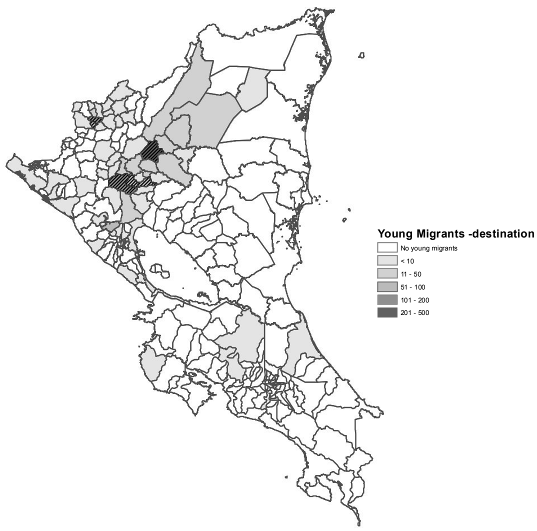


Figure 3. Distribution of rainfall (z-scores) by location

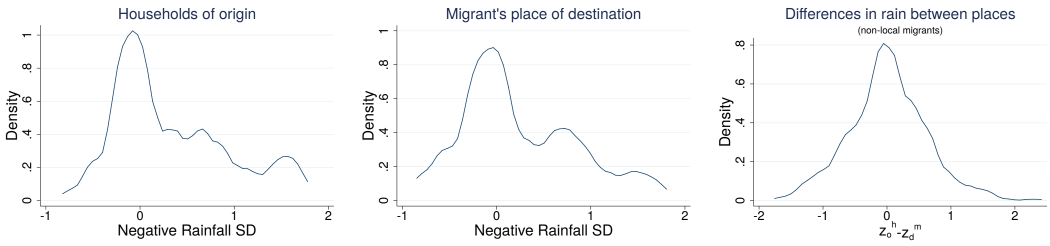
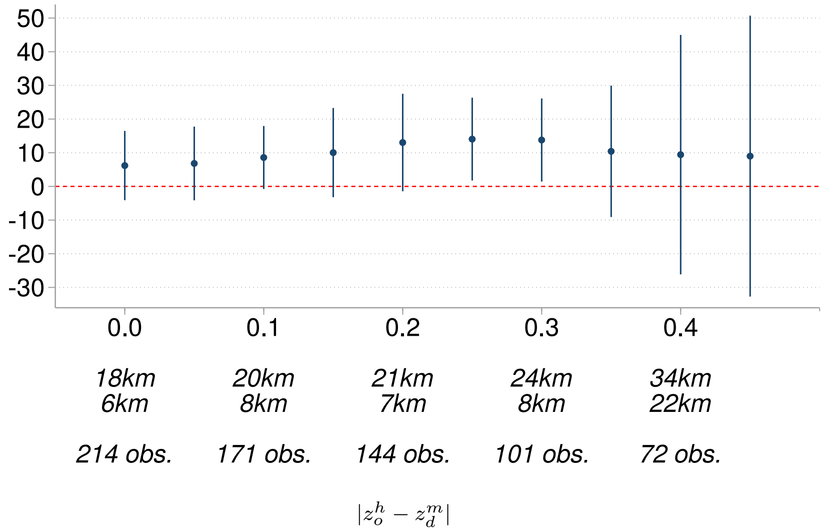
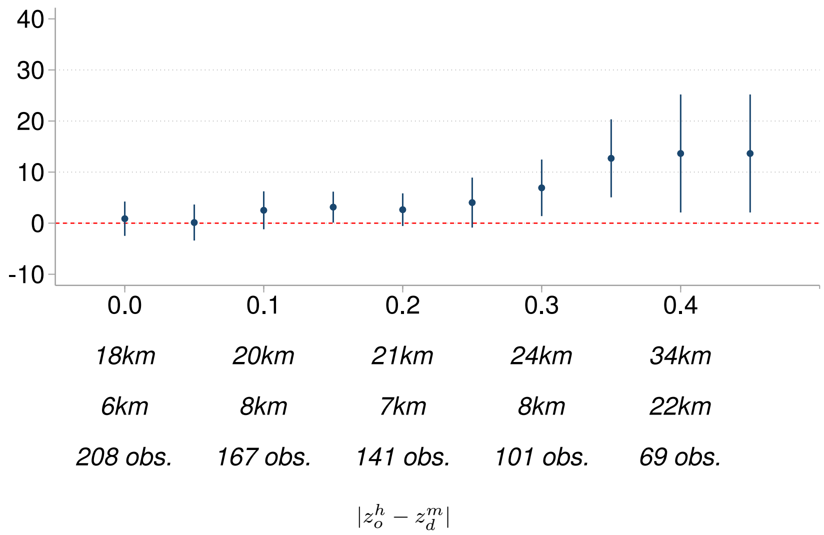


Figure 4. Impact of rainfall on remittances and transfers receipts. Non-local rural migrants.



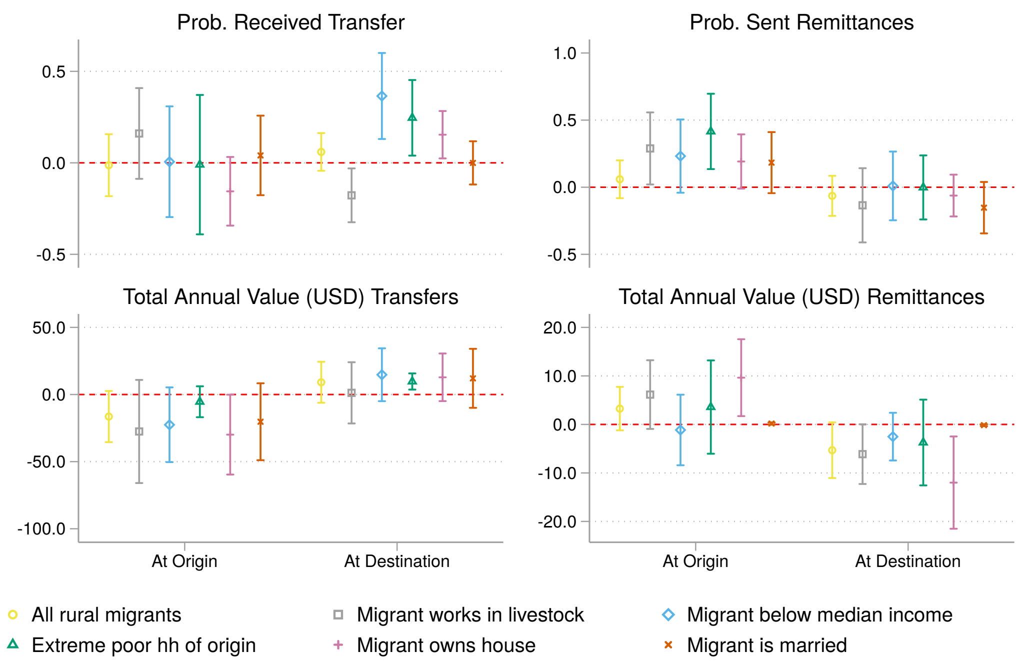
(a) At the destination. Value of transfers receipts (β^d_{Tr})



(b) At the origin. Value of remittances sent (β^o_R)

Note: Each figure plots the coefficient estimates (β^d_{Tr} and β^o_R respectively) of the running Equations 8 and 9 on the pool of migrants satisfying $|z_o^h - z_d^m| > x$, where x takes values from 0 to 0.45 at 0.05 intervals. Negative rainfall accounts for the deviations from the historical mean of the accumulated rain between June-July in 2009 divided by the standard deviation for each rainfall grid multiplied by minus one. Positive values represent the rainfall deficits with respect to the historical mean. All regressions include household and migrant level controls. The full list of controls is presented in section 5. Dependent values input max and min values for the 1% highest and lowest outliers. Confidence Intervals are set at 90%. Robust standard errors are adjusted for two-way clustering at the origin grid cell level and at the destination grid cell level. Average (top) and median (bottom) distances in kilometres between a migrant's location of origin and a migrant's location of destination are presented for each of the sub-samples, together with the number of observations for each regression.

Figure 5. Impact of rainfall on remittances and transfer receipts. Non-local rural migrants by category.



Note: The figure plots the coefficient estimates of running Equation 8 and 9 on several sub-samples of migrants. Negative rainfall accounts for the deviations from the historical mean of the accumulated rain between June-July in 2009 divided by the standard deviation for each rainfall grid multiplied by minus one. Positive values represent the rainfall deficits with respect to the historical mean. All regressions include household and migrant level controls. The full list of controls is presented in section 5. Dependent values input max and min values for the 1% highest and lowest outliers. Confidence Intervals are set at 90%. Robust standard errors are adjusted for two-way clustering at the origin grid cell level and at the destination grid cell level.

Table 1. Individual characteristics by destination (2010)

			Non-local migrants		
	Stayers	**Local migrants**	**all**	**rural**	**urban**
	(1)	(2)	(3)	(4)	(5)
Age (January, 2010)	17.83	0.01	-0.02	-0.01	-0.02**
		(0.02)	(0.01)	(0.02)	(0.01)
Female	0.39	0.25***	0.31***	0.32***	0.24***
		(0.03)	(0.03)	(0.04)	(0.05)
Grades attained	6.07	-0.60***	0.64**	-0.28	1.94***
		(0.14)	(0.31)	(0.29)	(0.44)
Currently working	0.93	0.02	-0.09***	-0.03	-0.16***
		(0.01)	(0.02)	(0.03)	(0.03)
Currently working in non-agriculture	0.24	-0.03	0.14***	-0.05	0.41***
		(0.02)	(0.04)	(0.04)	(0.03)
Currently studying	0.41	-0.14***	-0.04	-0.13***	0.10
		(0.02)	(0.04)	(0.04)	(0.07)
Currently working and studying	0.37	-0.11***	-0.09***	-0.15***	0.01
		(0.02)	(0.03)	(0.03)	(0.04)
Currently married	0.09	0.54***	0.38***	0.50***	0.13**
		(0.03)	(0.04)	(0.04)	(0.05)
Have children	0.17	0.31***	0.13***	0.24***	-0.09**
		(0.02)	(0.04)	(0.04)	(0.04)
House ownership	0.91	-0.12***	-0.32***	-0.20***	-0.44***
		(0.03)	(0.03)	(0.04)	(0.07)
Size of land (in logarithms)	9.86	-0.39***	-2.04***	-0.56***	-4.00***
		(0.11)	(0.28)	(0.18)	(0.21)
Total Annual Consumption per capita in 2010					
Household of origin	544.88	30.57*	63.84***	14.49	129.43***
		(18.19)	(22.63)	(24.79)	(40.28)
Household at destination	545.45	68.31*	659.89***	184.57***	1280.56***
		(38.86)	(146.16)	(51.00)	(242.99)
Motives behind the decision to migrate (sample of migrants)					
Work		0.02	0.11***	-0.03	0.27***
			(0.04)	(0.02)	(0.07)
Taken		0.20	-0.34***	-0.30***	-0.25***
			(0.03)	(0.04)	(0.03)
Change civil status		0.72	0.05	0.26***	-0.29***
			(0.05)	(0.05)	(0.04)
Study		0.00	0.11***	0.01	0.20***
			(0.03)	(0.02)	(0.06)
Better economic situation		0.05	0.07***	0.05*	0.07*
			(0.03)	(0.03)	(0.04)
Remittances and transfers (sample of migrants)					
Sent remittances		0.32	0.02	-0.02	0.06
			(0.04)	(0.03)	(0.04)
Received transfers		0.32	0.02	0.01	0.03
			(0.04)	(0.03)	(0.06)
Remitted and received transfers		0.22	-0.02	0.01	-0.05
			(0.03)	(0.03)	(0.04)
Annual value remittances (USD)		32.28	30.86**	-25.41***	74.31***
			(13.71)	(7.01)	(18.99)
Annual value transfers (USD)		37.61	5.70	-15.51	29.97*
			(11.46)	(9.59)	(15.57)
Net annual value transfers (USD)		-4.52	-13.31*	4.93	-34.28***
			(7.37)	(4.76)	(11.05)
Observations	2,468	480	384	233	151

Note: Column 1 presents the average value for the sample of stayers and of individuals in migrating households, Columns 2-5 report the differences in means by destination with respect to column 1. The sample is restricted to individuals whose households of origin were interviewed before August, 2010: N=3,332. Robust standard errors, in parentheses, are adjusted for two-way clustering at the origin grid cell level and at the destination grid cell level. *p<0.1, **p<0.05, ***p< 0.01.

Table 2. Impact of rainfall on household annual food production, first season harvest, income and consumption. Households at communities of origin.

	Households with migrants		Households without migrants	
outcome	**mean**	**Negative rainfall (z-scores)**	**mean**	**Negative rainfall (z-scores)**
	(1)	(2)	(3)	(4)
Food production (in logarithm points)				
Food production	4.93	-0.398**	4.82	-0.268***
		(0.15)		(0.066)
Grains produced	1.75	-0.471***	1.65	-0.230***
		(0.15)		(0.066)
Grains bought	1.65	0.289***	1.64	0.165***
		(0.088)		(0.057)
Final outcome of the first season harvest				
Sold	0.39	-0.0921	0.36	-0.137***
		(0.067)		(0.045)
Consumed	0.90	-0.0612	0.90	-0.0594***
		(0.037)		(0.019)
Lost	0.075	0.0321	0.059	0.0445***
		(0.035)		(0.016)
Household annual income (in logarithm points)				
Agricultural income	3.82	-0.800**	3.61	-0.639***
		(0.30)		(0.19)
Agricultural income p.c.	2.43	-0.582**	2.17	-0.493***
		(0.28)		(0.17)
Total sources of income	6.57	0.0341	6.96	-0.146**
		(0.16)		(0.065)
Total sources of income p.c.	4.95	0.0847	5.12	-0.150**
		(0.16)		(0.066)
Household annual consumption (in logarithm points)				
Total consumption p.c.	6.25	0.0680	6.20	0.00899
		(0.063)		(0.032)
Food consumption p.c.	5.77	0.113	5.68	-0.00488
		(0.071)		(0.041)
Non-food consumption p.c.	4.21	-0.0556	4.21	0.0196
		(0.099)		(0.054)
Obs.		318		1338

Note: Negative rainfall accounted for deviations from the historical mean of the accumulated rain between June-July in 2009, divided by the standard deviation for each rainfall grid cell multiplied by minus one. Positive values represent the rainfall deficits with respect to the historical mean. Columns (1)-(2) report the results for households interviewed before the end of the first harvest season in 2010 with non-local migrants between the ages of 15 and 21. Columns (3)-(4) report the results for households interviewed before the end of the first harvest season in 2010 with local migrants or with young adults between the ages of 15 and 21 living in the household. All regressions include household level controls. The full list of controls is presented in section 5. Robust standard errors, in parentheses, are clustered at the grid cell level. *p<0.1, **p<0.05, ***p< 0.01.

Table 3. Impact of rainfall on local and non-local migration.

		Coefficient of variation 2000-2008		Negative rainfall (z-scores)	
destination	**mean**	**origin**	**destination**	**origin**	**destination**
Surveyed individuals (N=3,284)					
Local migrants	0.14	0.0896		0.0127	
		(0.094)		(0.013)	
Non-local migrants	0.11	0.0584	0.00754	-0.00814	-0.0212
		(0.41)	(0.40)	(0.15)	(0.16)
Rural non-local migrants	0.072	0.0222	-0.0708	-0.0869	0.0606
		(0.34)	(0.34)	(0.099)	(0.11)
Urban migrants	0.038	0.0361	0.0783	0.0788	-0.0818
		(0.23)	(0.21)	(0.097)	(0.10)
Regional migrants surveyed (N=854)					
Local migrants	0.56	0.165		0.0962	
		(0.23)		(0.047)	
Rural migrants	0.29	-0.126	-0.249	-0.144*	0.0361
		(0.39)	(0.34)	(0.079)	(0.095)
Urban migrants	0.15	-0.000233	0.193	0.0810	-0.0829
		(0.30)	(0.18)	(0.067)	(0.090)
Differences in rainfall intensity between origin and destination (N=854)					
$\lvert z_o^h - z_d^m \rvert \geq 0.10$	0.22	-0.186	-0.202	-0.0937	0.0387
		(0.30)	(0.30)	(0.084)	(0.11)
$\lvert z_o^h - z_d^m \rvert \geq 0.25$	0.16	-0.190	-0.166	-0.0543	0.0222
		(0.26)	(0.28)	(0.080)	(0.10)
$\lvert z_o^h - z_d^m \rvert \geq 0.50$	0.083	-0.212	0.0563	-0.0458	0.0838
		(0.21)	(0.21)	(0.082)	(0.091)
$\lvert z_o^h - z_d^m \rvert \geq 0.75$	0.043	0.137	-0.229	-0.0441	0.0919
		(0.17)	(0.16)	(0.071)	(0.087)
$\lvert z_o^h - z_d^m \rvert \geq 0.90$	0.028	0.213	-0.201	-0.0554	0.0967
		(0.16)	(0.16)	(0.058)	(0.074)

Note: The coefficient of variation of accumulated rain between June-July from 2000 to 2008 at the migrants' location of origin and of destination, CV= $STD_{(00-08)}/MEAN_{(00-08)}$. Rainfall accounts for deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each rainfall grid cell multiplied by minus one. Positive values represent the rainfall deficits with respect to the historical mean. All regressions include household level controls. The full list of controls is presented in section 5. Robust standard errors, in parentheses, are adjusted for two-way clustering at the origin grid cell level and at the destination grid cell level. *p<0.1, **p<0.05, ***p< 0.01.

Table 4. Impact of Weather Shocks on Remittances and Transfer Receipts.

	Probability to		Total Annual Value (USD)		
	Receive Transfers	Remit	Transfers	Remittances	Net Transfers
			Non-Local Migrants		
Negative rainfall (z-scores): origin	-0.07	0.09*	-23.84**	28.34*	-36.30**
	(0.07)	(0.05)	(9.73)	(16.32)	(17.80)
Negative rainfall (z-scores): destination	0.05	-0.05	16.22	-13.95	17.82*
	(0.06)	(0.07)	(10.92)	(12.05)	(10.15)
Outcome mean	0.35	0.33	14.40	18.96	-8.22
Obs	364	355	362	354	353
P-value: $\beta_o = -\beta_d$	0.855	0.532	0.278	0.112	0.122
			Local Migrants		
Negative rainfall (z-scores): origin	-0.05	0.00	1.19	-2.49	0.11
	(0.05)	(0.04)	(5.56)	(2.49)	(4.05)
Outcome mean	0.31	0.32	11.71	9.64	-0.29
Obs	470	445	467	442	441

Notes: Negative rainfall accounted for deviations from the historical mean of the accumulated rain between June-July in 2009, divided by the standard deviation for each rainfall grid cell multiplied by minus one. Positive values represent the rainfall deficits with respect to the historical mean. All regressions include household and migrant level controls. The full list of controls is presented in section 5. Robust standard errors, in parentheses, are adjusted for two-way clustering at the origin grid cell level and at the destination grid cell level. *p<0.1, **p<0.05, ***p< 0.01.

Table 5. Impact of rainfall on household annual food production, first season harvest, income and consumption. Non-local migrants by destination. Standard errors are clustered by grid cell of origin.

	Non-local migrants surveyed before harvest first season 2010			
	Urban migrants		**Rural migrants**	
outcome	**mean**	**Negative rainfall (z-scores)**	**mean**	**Negative rainfall (z-scores)**
Food production (in logarithm points)				
Food Production	0.43	-0.873	1.79	0.0182
		(0.54)		(0.16)
Grains produced	0.20	-0.674	1.18	-0.0996
		(0.44)		(0.12)
Grains bought	1.97	-0.542	1.58	0.421***
		(0.83)		(0.15)
Final outcome of the first season harvest				
Sold	0.067	0.357***	0.25	-0.0712
		(0.089)		(0.082)
Consumed	0.12	0.655**	0.67	-0.156**
		(0.23)		(0.075)
Lost	0	0	0.020	-0.0250
		(0)		(0.029)
Household annual income (in logarithm points)				
Agricultural income	1.66	1.070	5.55	-0.696*
		(1.90)		(0.40)
Agricultural income p.c.	0.51	1.121	2.43	-0.770**
		(1.01)		(0.32)
Total sources of income	7.97	-3.469	8.55	-0.0608
		(2.17)		(0.36)
Total sources of income p.c.	4.85	-1.280	4.96	-0.138
		(1.91)		(0.27)
Household annual consumption (in logarithm points)				
Total consumption p.c.	7.79	-0.102	7.18	-0.0849
		(0.48)		(0.095)
Food consumption p.c.	7.13	0.0654	6.62	-0.0764
		(0.55)		(0.098)
Non-food Consumption p.c.	5.99	-0.494	5.39	-0.159
		(0.67)		(0.14)
Obs.		77		201

Note: Negative rainfall accounted for deviations from the historical mean of the accumulated rain between June-July in 2009, divided by the standard deviation for each rainfall grid cell multiplied by minus one. Positive values represent the rainfall deficits with respect to the historical mean. All regressions include household and migrant level controls. The full list of controls is presented in section 5. Robust standard errors, in parentheses, are adjusted for two-way clustering at the origin grid cell level and at the destination grid cell level. *p<0.1, **p<0.05, ***p< 0.01.

Table 6. Impact of Weather Shocks on Remittances and Transfer Receipts. Non-Local Migrants by Destination.

	Probability to		**Total Annual Value (USD)**		
	Receive Transfers	**Remit**	**Transfers**	**Remittances**	**Net Transfers**
			Urban Non-Local Migrants		
Negative rainfall (z-scores): origin	-0.18**	0.10	-36.69**	65.08*	-76.47**
	(0.08)	(0.11)	(16.31)	(33.00)	(32.52)
Outcome mean	0.36	0.37	24.94	41.67	-24.60
Obs	139	136	138	136	135
			Rural Non-Local Migrants		
Negative rainfall (z-scores): origin	-0.01	0.06	-16.42	3.26	-9.49*
	(0.10)	(0.08)	(11.34)	(2.66)	(5.26)
Negative rainfall (z-scores): destination	0.06	-0.06	9.13	-5.31	7.76
	(0.06)	(0.09)	(9.07)	(3.41)	(5.57)
Outcome mean	0.34	0.31	9.07	7.41	0.06
Obs	225	219	224	218	218
P-value: $\beta_o = -\beta_d$	0.620	0.937	0.244	0.391	0.659

Note: Negative Rainfall SD accounts for deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each rainfall grid multiplied by minus one. Positive values represent rainfall deficits with respect to the historical mean. All regressions include household and migrant level controls. The full list of controls is presented in section 5. Dependent values imputed max and min values for the 1% highest and lowest outliers. Robust standard errors, in parentheses, are adjusted for two-way clustering at the origin grid cell level and at the destination grid cell level. *p<0.1, **p<0.05, ***p< 0.01.

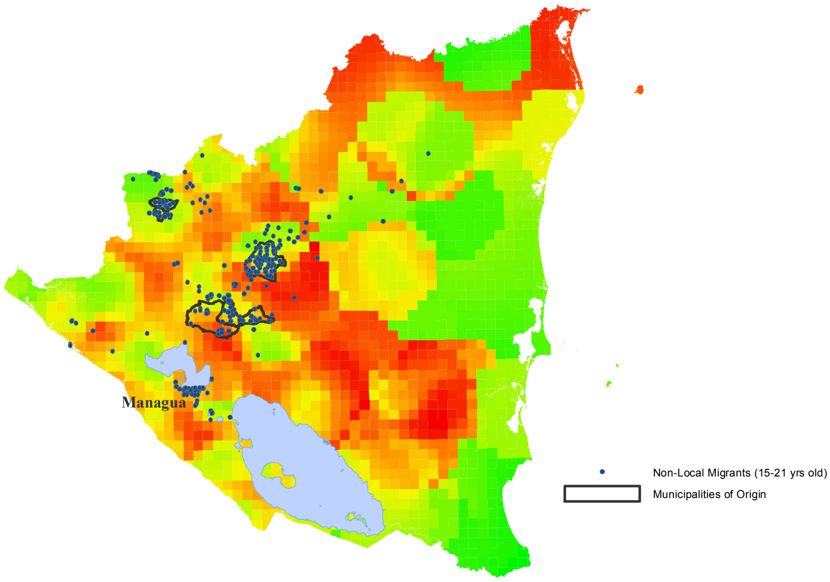
Table 7. Impact of rainfall on household composition, assets, and livestock. Households of origin communities.

	Households with migrants		Households without migrants	
outcome	**mean**	**Negative rainfall (z-scores)**	**mean**	**Negative rainfall (z-scores)**
	(1)	(2)	(3)	(4)
Household members	6.04	-0.582**	6.87	0.0216
		(0.22)		(0.12)
Household members by age cohort				
Ages between 0-6	0.68	-0.116	0.78	0.0154
		(0.087)		(0.040)
Ages between 7-14	1.37	-0.366***	1.47	0.0748
		(0.10)		(0.057)
Ages between 15-30	1.89	0.0634	2.54	-0.0706
		(0.14)		(0.067)
Ages between 31-60	1.60	-0.0106	1.68	0.00958
		(0.073)		(0.025)
Ages over 61	0.41	-0.0417	0.36	-0.00578
		(0.045)		(0.024)
Household members by age cohort not living with their parents				
Ages between 0-6 (no 1 parent)	0.41	-0.0505	0.46	0.0583
		(0.076)		(0.042)
Ages between 7-14 (no 1 parent)	0.39	-0.159*	0.32	0.0563
		(0.091)		(0.041)
Assets				
Own productive assets	1.84	0.0500	1.76	-0.151**
		(0.13)		(0.072)
Own assets	3.84	-0.152	3.70	-0.280**
		(0.20)		(0.12)
Livestock				
Number of pigs	0.99	0.259	0.87	-0.196**
		(0.17)		(0.096)
Number of chickens	10.3	-1.190	10.3	-1.355*
		(0.88)		(0.69)
Number of cows	1.78	-0.509	1.84	-0.783
		(0.42)		(0.75)
Obs.		318		1,338

Note: Negative rainfall accounted for deviations from the historical mean of the accumulated rain between June-July in 2009, divided by the standard deviation for each rainfall grid cell multiplied by minus one. Positive values represent the rainfall deficits with respect to the historical mean. Columns (1)-(2) report the results for households interviewed before the end of the first harvest season in 2010 with non-local migrants between the ages of 15 and 21. Columns (3)-(4) report the results for households interviewed before the end of the first harvest season in 2010 with local migrants or with young adults between the ages of 15 and 21 living in the household. All regressions include household level controls. The full list of controls is presented in section 5. Robust standard errors, in parentheses, are clustered at the grid cell level. *p<0.1, **p<0.05, ***p< 0.01.

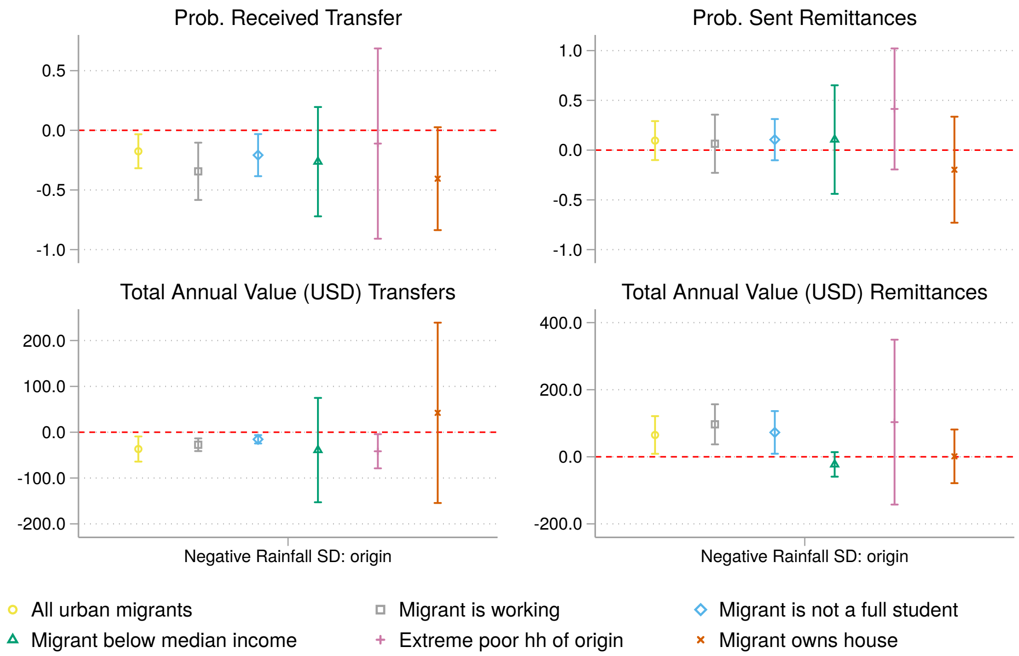
Appendix A. Appendix

Figure A1. Distribution of non-Local migrants and rainfall intensity in 2009



Note: Accumulated rain between June-July in 2009. The data are available for a grid of 0.075°(every 8 km) and are interpolated from weather stations (from the Nicaraguan Institute of Territorial Studies, INETER) and satellite data measured at a resolution of 0.1875°(every 20 km) from NARR (the North American Regional Reanalysis) Uribe (2011). Blue dots represent the location of the sample of young migrants (15-21 years old) surveyed in 2009.

Figure A2. Impact of rainfall on remittances and transfer receipts. Non-local urban migrants by category.



Note: The figure plots coefficient estimates of running Equations 8 and 9 on several sub-samples of urban migrants. Negative rainfall accounted for deviations from the historical mean of the accumulated rain between June-July in 2009, divided by the standard deviation for each rainfall grid cell multiplied by minus one. Positive values represent the rainfall deficits with respect to the historical mean. All regressions include household level controls. The full list of controls is presented in section 5. Dependent values input max and min values for the 1% highest and lowest outliers. Confidence Intervals are set at 90%. Robust standard errors are adjusted for two-way clustering at the origin grid cell level and at the destination grid cell level.

Table A1. Baseline characteristics by location.

	Stayers	Local migrants	Non-local migrants		
			all	rural	urban
	(1)	(2)	(3)	(4)	(5)
Phase I *RPS*	0.50	0.03	-0.02	0.05***	-0.11*
		(0.03)	(0.01)	(0.02)	(0.06)
Individual characteristics					
Age (Nov, 2000)	9.19	0.70***	0.64***	0.44***	0.85***
		(0.12)	(0.10)	(0.10)	(0.20)
Female	0.39	0.25***	0.30***	0.32***	0.24***
		(0.03)	(0.03)	(0.04)	(0.05)
Grades attained	0.73	0.11	0.37***	0.09	0.75***
		(0.08)	(0.09)	(0.06)	(0.15)
Child of the household head	0.88	-0.20***	-0.15***	-0.15***	-0.12***
		(0.02)	(0.03)	(0.03)	(0.04)
Father at home	0.83	-0.08***	-0.16***	-0.15***	-0.15***
		(0.03)	(0.02)	(0.03)	(0.04)
Mother at home	0.95	-0.04**	-0.09***	-0.07***	-0.11***
		(0.02)	(0.01)	(0.02)	(0.02)
Household head characteristics					
Female	0.11	0.03	0.02	-0.01	0.07
		(0.02)	(0.03)	(0.03)	(0.05)
Age	43.18	3.77***	2.68***	2.07**	3.21***
		(0.67)	(0.56)	(0.91)	(0.93)
Grades attained	1.64	-0.35**	-0.11	-0.09	-0.14
		(0.14)	(0.11)	(0.15)	(0.20)
No education	0.51	0.09**	0.04	0.02	0.06
		(0.03)	(0.03)	(0.03)	(0.05)
Agriculture activity	0.84	-0.02	0.01	0.03**	-0.03
		(0.02)	(0.02)	(0.01)	(0.04)
Number of children	4.96	-0.18*	-0.17	-0.32*	0.08
		(0.10)	(0.16)	(0.18)	(0.30)
Household characteristics					
Total consumption p.c (log)	7.74	-0.07***	0.01	-0.01	0.04
		(0.02)	(0.02)	(0.03)	(0.03)
House ownership	0.85	-0.03	0.02	-0.02	0.08***
		(0.02)	(0.02)	(0.03)	(0.02)
Land size (in logarithm points)	8.18	-0.17	0.44**	0.10	0.89***
		(0.16)	(0.21)	(0.26)	(0.23)
Livestock	0.16	-0.02	0.04	-0.02	0.12**
		(0.02)	(0.03)	(0.04)	(0.05)
Vegetation index	0.88	0.00	-0.00	0.02***	-0.03***
		(0.00)	(0.00)	(0.00)	(0.01)
Living in a lit area	0.11	0.01	-0.01	-0.01	-0.00
		(0.01)	(0.03)	(0.03)	(0.04)
Distance school (min)	25.39	1.25	-0.14	3.80*	-6.11*
		(1.58)	(1.18)	(2.27)	(3.19)
Altitude	627.62	14.42	-9.59	25.64**	-61.70**
		(13.05)	(13.32)	(9.74)	(30.51)
Household composition: household members					
Ages 0-4	1.07	0.16***	-0.05	0.00	-0.13**
		(0.05)	(0.05)	(0.07)	(0.05)
Ages 5-15	3.51	0.18***	0.08	0.08	0.08
		(0.07)	(0.06)	(0.06)	(0.15)
Ages 16-30	1.65	0.19**	0.33***	0.25*	0.40**
		(0.07)	(0.12)	(0.14)	(0.15)
Ages 31-60	1.59	0.13**	0.05	0.01	0.10
		(0.06)	(0.05)	(0.07)	(0.07)
Ages over 61	0.16	0.11***	0.07**	0.11*	0.02
		(0.03)	(0.04)	(0.06)	(0.04)

Note: Column (1) presents the average value for the sample of stayers and of individuals in migrating households, while Columns (2)-(5) report the differences in means (standard errors in parentheses) by destination with respect to Column (1). Robust standard errors are adjusted for two-way clustering at the origin grid cell level and at the destination grid cell level. *p<0.1, **p<0.05, ***p< 0.01.

Table A2. Correlates of migration and rainfall deficit. Individual and household characteristics.

	Joint significance test: P-values				
			Household		
	Individual characteristics	Age dummies	wealth	composition	head characteristics
	(1)	(2)	(3)	(4)	(5)
Surveyed individuals (N=3,284)					
Urban migrants	0.007***	0.108	0.103	0.308	0.024**
Local migrants	0.000***	0.134	0.002***	0.000***	0.322
Non-local migrants	0.000***	0.299	0.785	0.000***	0.168
Rural non-local migrants	0.000***	0.096*	0.906	0.000***	0.060*
Urban migrants	0.211	0.288	0.353	0.506	0.138
Regional migrants surveyed (N=854)					
Local migrants	0.629	0.464	0.257	0.007***	0.567
Rural migrants	0.818	0.506	0.494	0.087*	0.015**
Urban migrants	0.586	0.523	0.556	0.728	0.641
Difference in rainfall intensity between origin and destination (N=854)					
$\|z_o^h - z_d^m\| \geq 0.10$	0.223	0.614	0.734	0.006***	0.058*
$\|z_o^h - z_d^m\| \geq 0.25$	0.592	0.754	0.271	0.421	0.073*
$\|z_o^h - z_d^m\| \geq 0.50$	0.814	0.924	0.907	0.652	0.595
$\|z_o^h - z_d^m\| \geq 0.75$	0.087*	0.798	0.569	0.636	0.265
$\|z_o^h - z_d^m\| \geq 0.90$	0.396	0.512	0.374	0.817	0.254
Correlates with rainfall (N=3,284)					
Negative rainfall at origin	0.571	0.829	0.259	0.432	0.531
Negative rainfall at destination	0.260	0.460	0.343	0.814	0.402

Note: All regressions,except the last two rows, include as controls the negative rainfall at origin and at destination in standard deviation units. In addition, all regressions include household and migrant level controls. The full list of controls is presented in section 5. Columns (1)-(5) report the p-values for a joint significance test of the following variables grouped in categories: **Individual characteristics:** migrant's years of education, whether the migrant was female and whether the migrant was a beneficiary of the CCT; **age:** year of migrant's age dummies; **household wealth:** whether the household owned the house, log of land size and log of per capita expenditures; **household composition:** whether respondent is the child of household head, dummies for whether the migrant's mother and father lived in the house, household composition dummies (by age groups);**household head characteristics:** number of children of the household head, years of education of the household head, age of the household head, age of the household head squared, and dummy variables for whether the household head was active in agriculture, the household head had no completed grades of schooling, and was female. Robust standard errors are adjusted for two-way clustering at the origin grid cell level and at the destination grid cell level. *p<0.1, **p<0.05, ***p< 0.01.

Table A3. Impact of rainfall on remittances and transfer receipts. Including rainfall in urban areas. Urban migrants.

	Probability to		**Total annual value (USD)**		
	receive transfers	**remit**	**transfers**	**remittances**	**net transfers**
Negative rainfall (z-scores): origin	-0.16**	0.09	-37.28**	69.99*	-80.54**
	(0.08)	(0.12)	(15.81)	(34.30)	(33.66)
Negative rainfall (z-scores): destination	-0.12	0.10	6.25	-47.15	39.22
	(0.22)	(0.22)	(29.26)	(36.45)	(39.36)
Outcome mean	0.36	0.37	24.94	41.67	-24.60
Obs	139	136	138	136	135
P-value: $\beta_o = -\beta_d$	0.286	0.408	0.407	0.471	0.244

Note: Negative rainfall accounted for deviations from the historical mean of the accumulated rain between June-July in 2009, divided by the standard deviation for each rainfall grid cell multiplied by minus one. Positive values represent the rainfall deficits with respect to the historical mean. All regressions include household level controls. The full list of controls is presented in section 5. Dependent values input max and min values for the 1% highest and lowest outliers. Robust standard errors are adjusted for two-way clustering at the origin grid cell level and at the destination grid cell level. *p<0.1, **p<0.05, ***p< 0.01.

Table A4. Impact of rainfall on remittances and transfer receipts. Local and non-Local migrants 18-21 years old.

	Probability to		Total annual value (USD)		
	receive transfers	remit	transfers	remittances	net transfers
			Non-local migrants		
Negative rainfall (z-scores): origin	-0.10	0.04	-32.36**	37.79	-48.50**
	(0.07)	(0.08)	(14.30)	(22.52)	(22.80)
Negative rainfall (z-scores): destination	0.02	-0.10	31.58*	-20.33	27.94*
	(0.05)	(0.11)	(16.06)	(16.96)	(15.29)
Outcome mean	0.35	0.37	16.27	26.34	-15.38
Obs	243	243	241	242	241
			Local migrants		
Negative rainfall (z-scores): origin	-0.04	-0.00	-2.13	-5.41	-1.25
	(0.05)	(0.05)	(7.19)	(4.60)	(4.24)
Outcome mean	0.35	0.38	15.31	12.71	-1.39
Obs	322	321	320	320	319
			Urban migrants		
Negative rainfall (z-scores): origin	-0.25	0.02	-41.71**	79.68*	-100.68**
	(0.17)	(0.19)	(19.46)	(40.60)	(41.59)
Outcome mean	0.36	0.44	27.16	56.01	-38.79
Obs	101	101	100	101	100
			Non-local rural migrants		
Negative rainfall (z-scores): origin	-0.04	-0.05	-15.38	3.60	-8.36
	(0.14)	(0.16)	(13.10)	(5.00)	(6.08)
Negative rainfall (z-scores): destination	-0.01	-0.12	13.84	-6.11	8.69
	(0.08)	(0.13)	(14.49)	(5.53)	(7.72)
Outcome mean	0.35	0.34	10.15	9.53	-2.23
Obs	142	142	141	141	141

Note: Negative Rainfall accounts for deviations of accumulated rain between June-July in 2009 from the historical mean divided by the standard deviation for each rainfall grid cell multiplied by minus one. Positive values represent the rainfall deficits with respect to the historical mean. All regressions include household level controls. The full list of controls is presented in section 5. Dependent values input max and min values for the 1% highest and lowest outliers. Robust standard errors are adjusted for two-way clustering at the origin grid cell level and at the destination grid cell level. *p<0.1, **p<0.05, ***p< 0.01.